

Trace Element Abundance & Human Epidemiology: the Tellus Case Study

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Outline

- Background to Tellus
- Project aims
- Why is this important?
- Methods applied
- Results so far
- Future work

What is Tellus?

Project launched in 2004 to map the whole of Northern Ireland, and was completed 2006.

- Soils sampled at 20 and 50 cm depths on a regular grid at one site per 2 km².
- Soils in urban areas were sampled on an average of four sites per 1 km² and one site per 1 km² was sampled for organic compounds.
- Streams sediments and waters: sampled at an average of one site per 2 km².
- Airborne radiometric survey collected magnetics, conductivity & radioactivity along flight lines 200 m apart and 56-200 m above the surface.



Stream Sampling



Soil Sampling



Aerial survey



Project Aims

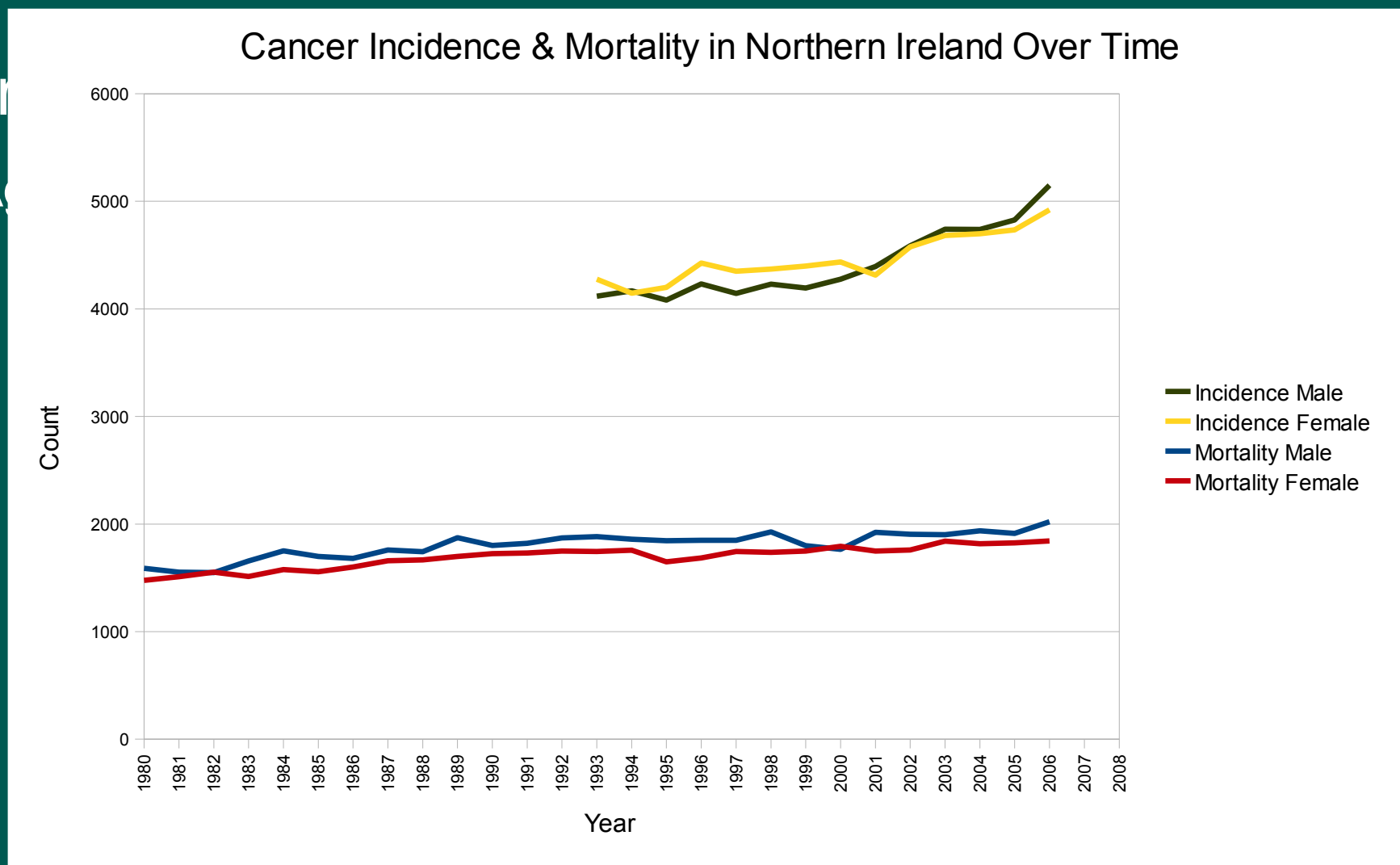
- Test if there is a correlation between soil & water borne trace elements and disease (primarily cancers) in Northern Ireland.
- Estimate the bioavailability of the chemicals of interest on a subset of the Tellus data.
- Identify the potential pathways for exposure.



Why is this Important?

- Cancer is the most common cause of death in Northern Ireland.

Major
A

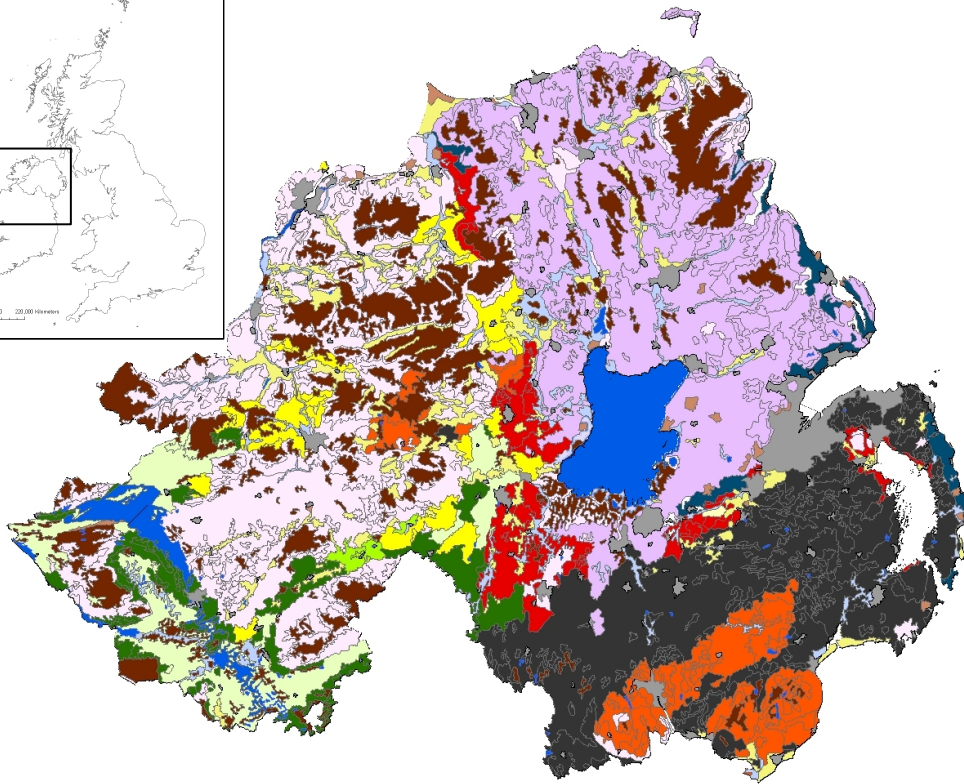
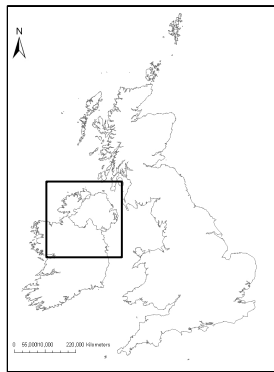


Why Northern Ireland?

NI geology is a microcosm for the rest of the UK and Ireland.

High resolution sampling of Tellus data.

NICR complete incidence of all cancers occurring 1993 – 2003, mortality up to 2004.



Legend

NI_SOIL_250K

<all other values>

SOIL_PAREN

Alluvium

Basalt

Calp

Chalk

Clogher Valley Limestone

Limestone

Disturbed

Granite

Carboniferous Sandstone

Red Trias Sandstone

Lake Sand

Sand and Gravel

Marl

Peats

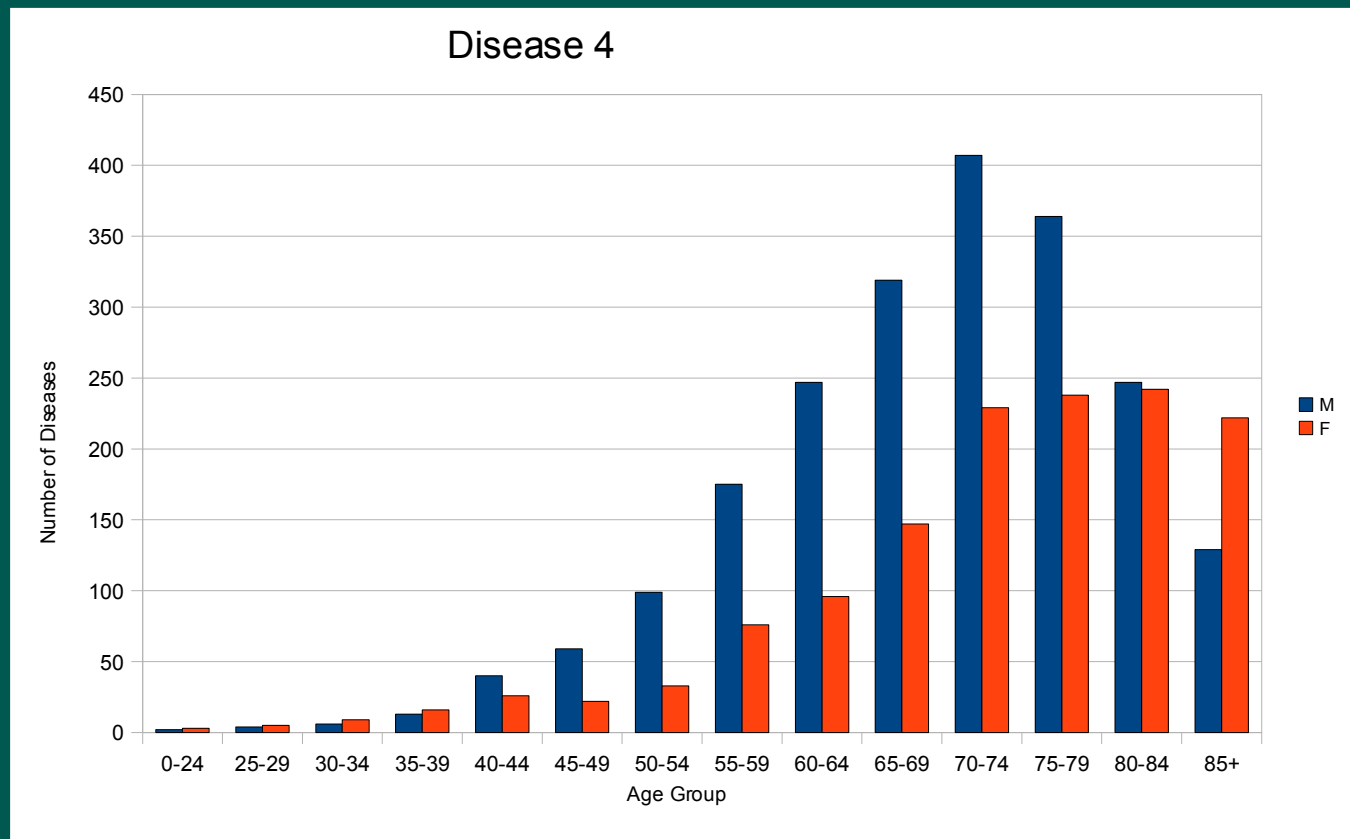
Shale

Urban

Water

The NICR Data

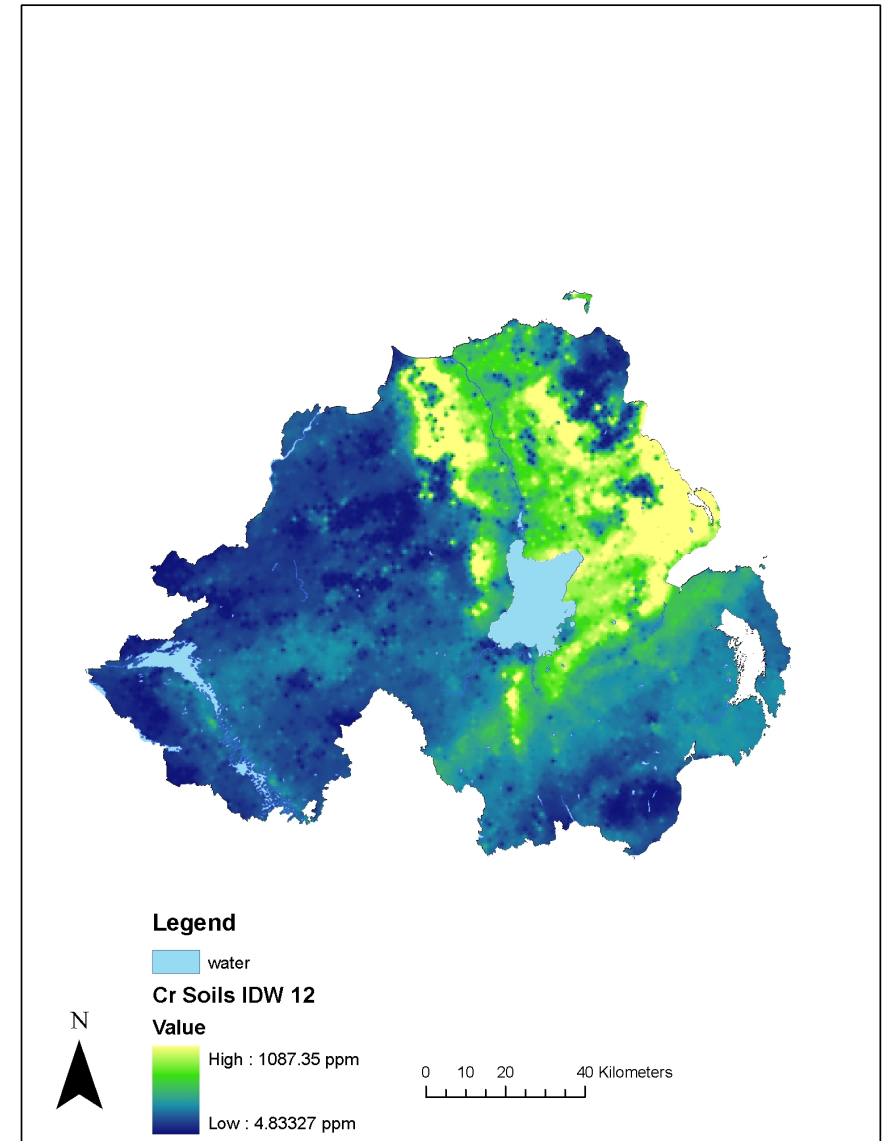
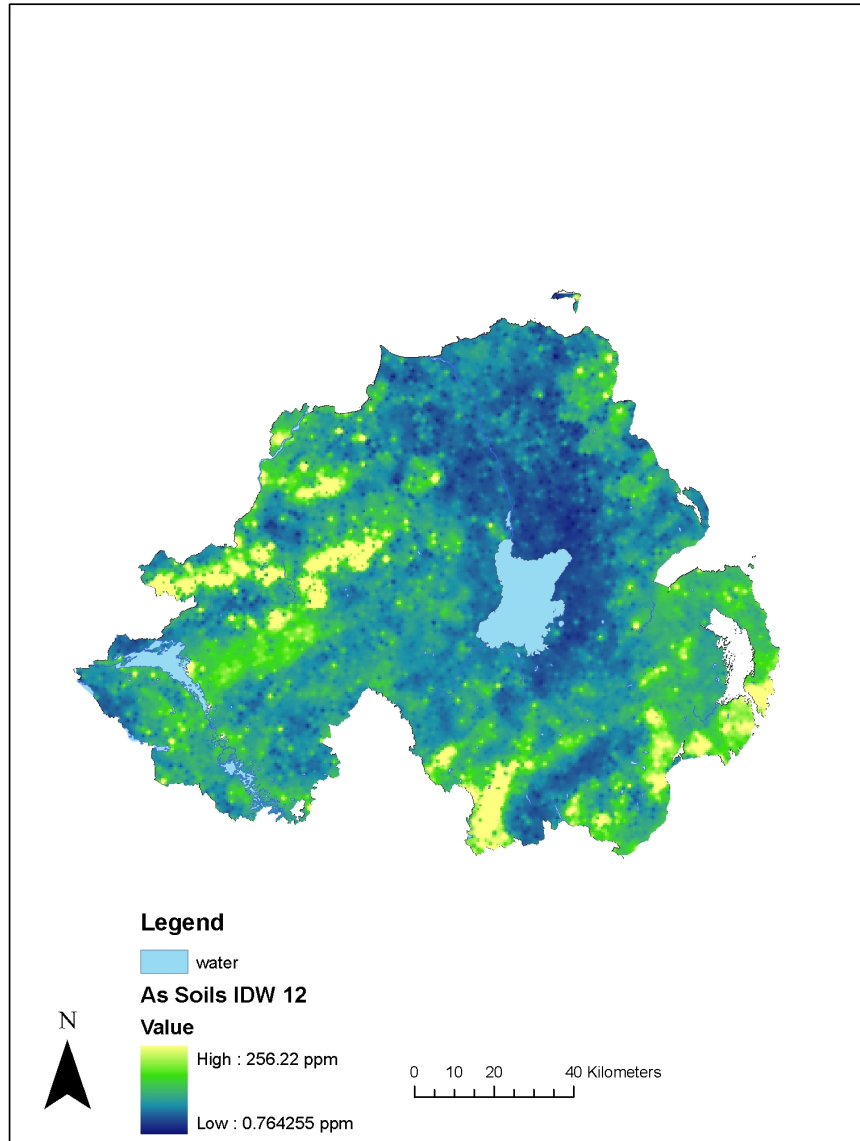
- 15 cancer data sets & 1 kidney disease data set
 - postcode, age bracket (0-4, 5-9, 10-14 etc), gender & disease code.
 - Aggregated postcodes to wards.



The Methods

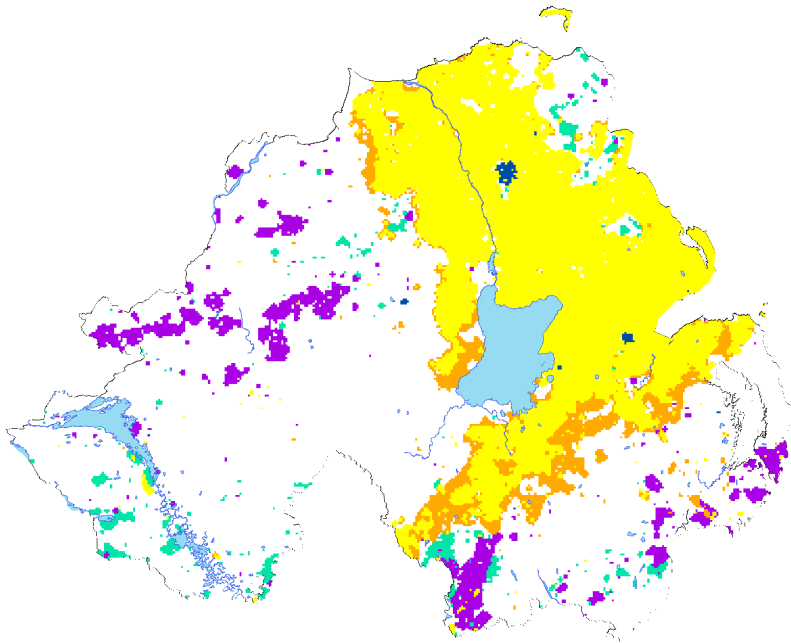
- Age standardisation of the first 8 diseases – takes into account the 12 years over which the data are aggregated and the age structure of the population in which they occur
- Mapping the trace elements in the soils
- Mapping the diseases & variograms
- Cluster Hunting (GAM)
- R – DCluster tools
- Local Cluster Analysis (Local Moran's I)
- Geographically Weighted Regression

Tellus trace elements in shallow soils



Soil Guideline Values

Areas where Soil Guideline Values are exceeded.



Legend

- water
- 1 Pb areas over SGV (450ppm)
- 1 Ni areas over SGV (50ppm)
- 1 Cr areas over SGV (130ppm)
- 1 As areas over SGV (20ppm)
- 1 Cd areas over SGV (1ppm)

0 5 10 20 Kilometers
|-----|

Arsenic	20 ppm
Cadmium	1 ppm
Chromium	130 ppm
Nickel	50 ppm
Lead	450 ppm

The Results

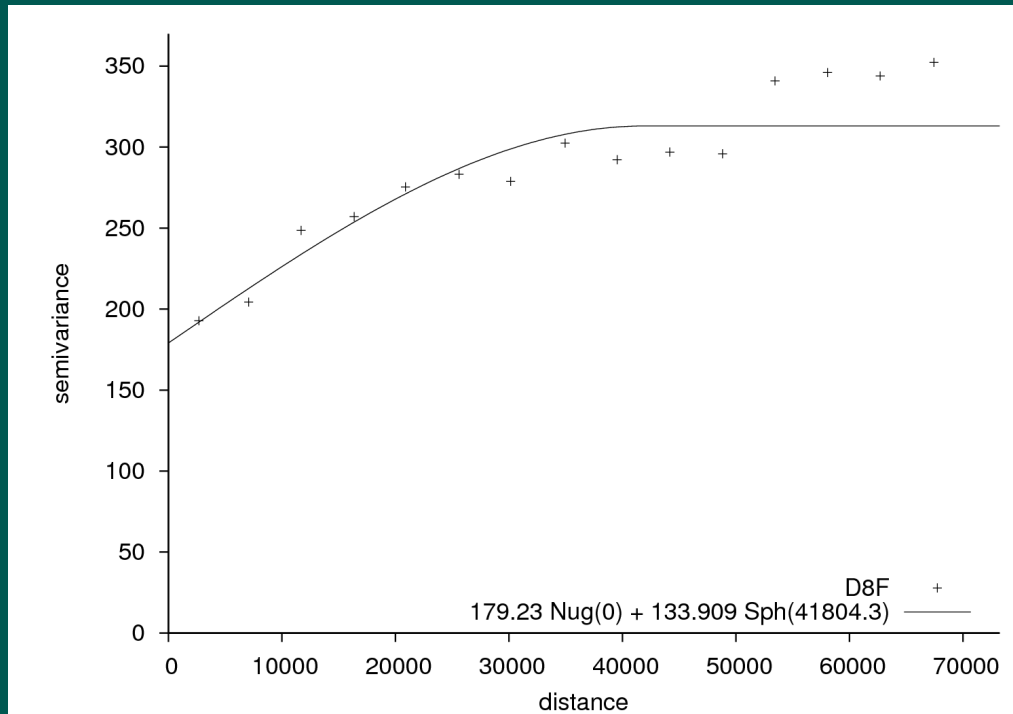
- Mapping the diseases at postcode level just showed up the urban centres.
- Cluster Hunter (GAM)¹ did not identify any hotspots in the raw data.
- DCluster:
 - χ^2 test (does the observed disease rate depart significantly from the expected distribution?) - No, all are Poisson-ish.
 - Moran's I test for autocorrelation – first 8 datasets show slight positive correlation.



	0.1956	0.001
	0.2201	0.001
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	0.2231	0.001
	0.4319	0.001
	0.3029	0.001

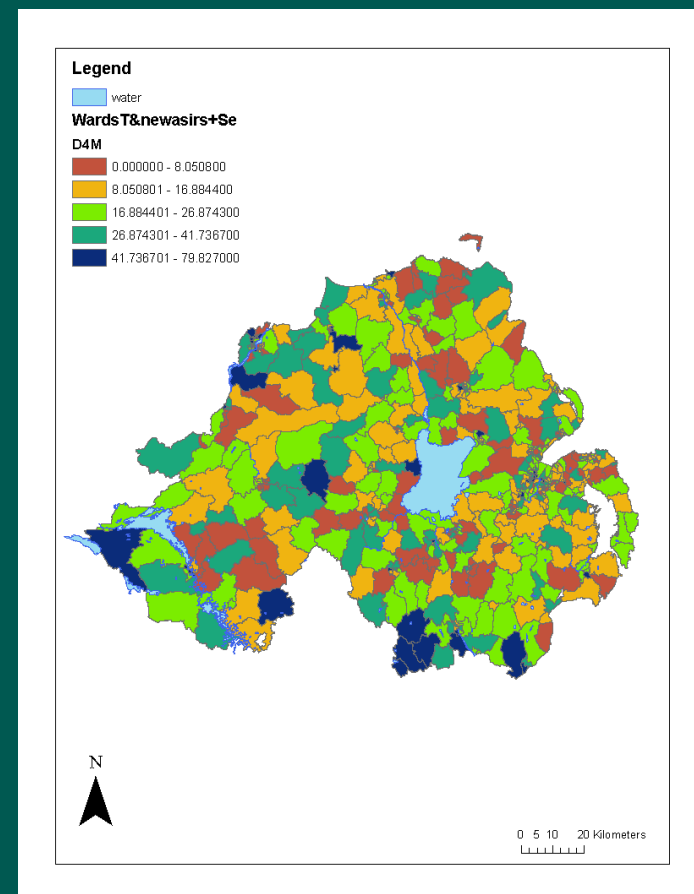
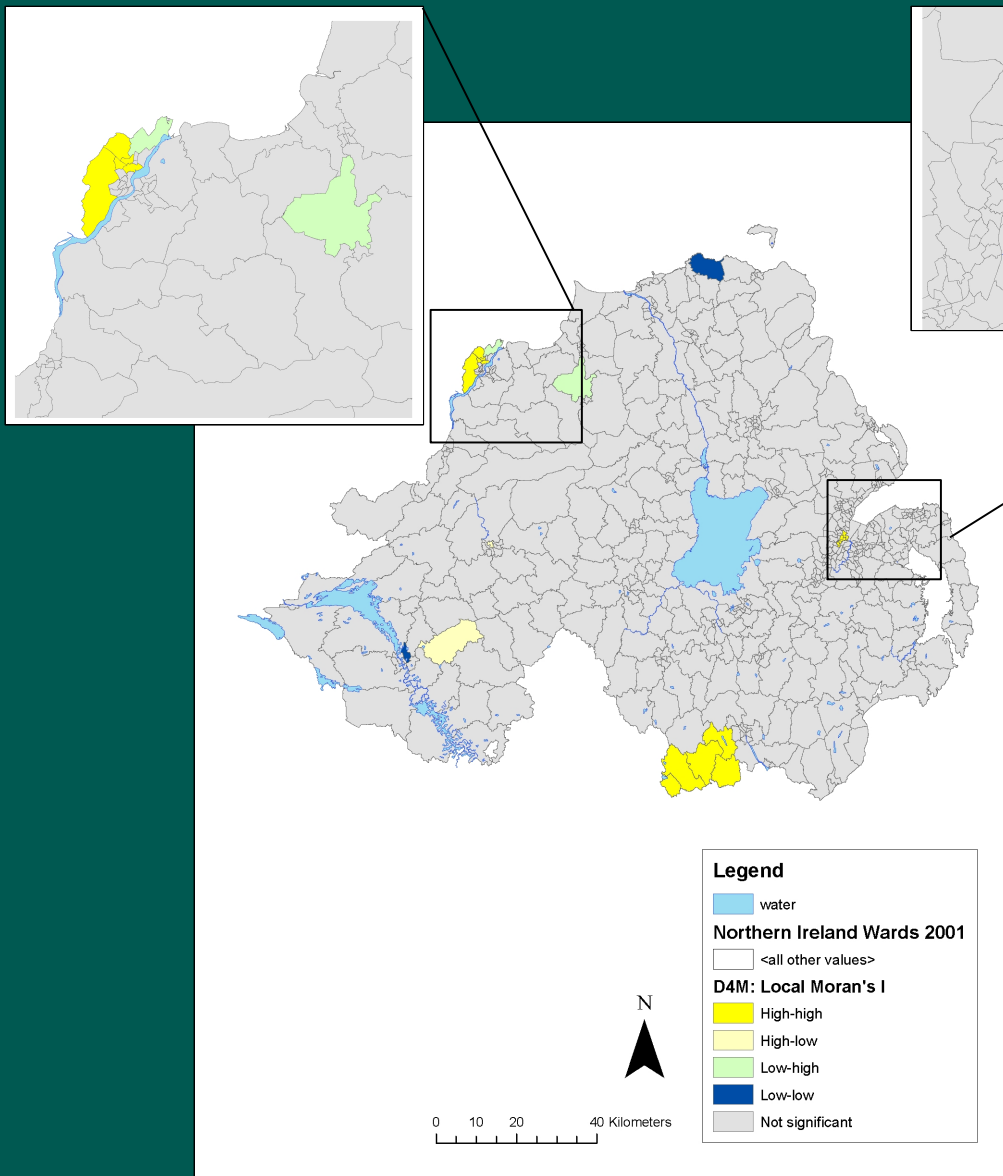
¹ www.ccg.leeds.ac.uk/software/gam/docs/simplerun.html

The Results



D8F is the only dataset of the first batch to show clear spatial structure – all the other variograms have no clear spatial structure left after taking out the effect of age.

Local Moran's I



High-High	16
High-Low	2
Low-High	2
Low-Low	2
Not Significant	560

Geographically Weighted Regression

- Software by NCG, University of Maynooth: GWR 3.0.
- Run all diseases & all trace elements at once – everything correlates with everything else.
- Run each disease against each trace element one by one – local R^2 correlations are even stronger.
- Test with random numbers – that correlates too!!??

Future Work

- Test the GWR implementations in R, ArcGIS and Terraseer STIS to see if they give the same results.
- Carry out a bioaccessibility study on a subset of Tellus soil samples to estimate bioavailability using the Unified BARGE Method, as developed at BGS.
- Use the 1 km² grid census to improve the resolution of the study.



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Stream Sampling



Soil Sampling



Aerial survey

<http://www.bgs.ac.uk/gsni/Tellus/index.html>

What is Tellus?

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- Airborne radiometric survey collected magnetics, conductivity & radioactivity along flight lines 200 m apart and 56-200 m above the surface.

TELLUS

Nearly 20,000 samples in total, covering surface and deep soils, stream sediments and stream waters on a regular grid, analysed by xrf for more than 50 elements and compounds

Project Aims

- Test if there is a correlation between soil & water borne trace elements and disease (primarily cancers) in Northern Ireland.
- Estimate the bioavailability of the chemicals of interest on a subset of the Tellus data.
- Identify the potential pathways for exposure.



Compare spatial relationship between trace element abundances (tellus) and human disease patterns (NICR)

Estimate bioavailability from bioaccessibility studies on a subset of tellus

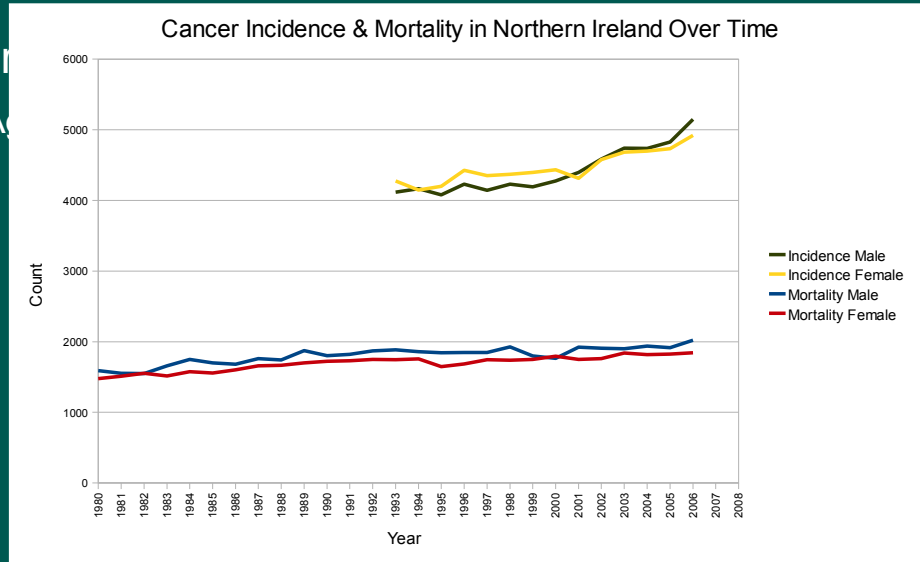
Look for relevant potential pathways of exposure

What I am not doing: Cancer Risk or Prediction Maps

Why is this Important?

- Cancer is the most common cause of death in Northern Ireland.

Major
A



Data from <http://www.northernireland.gov.uk/news/news-dfp/news-dfp-march-2009/news-dfp-190309-almost-4000-deaths.htm>

In 1978, Cancer accounted for 18% of all deaths

2008

NI, 27%.

UK cancer mortality 24%

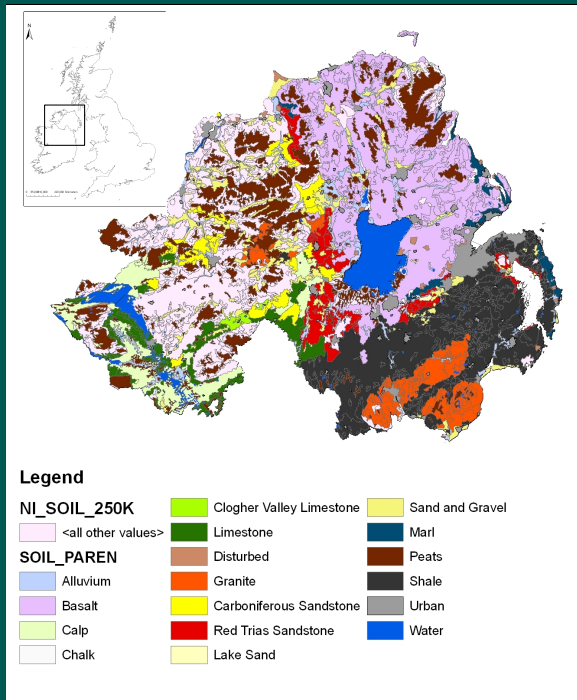
European cancer mortality 19%

UK being streamlined with europe in many things,
why not cancer rates?

Environmental exposures are only one of many
known factors in the aetiology of cancer

Throw a variety of methods at the data and see what
sticks? Fishing for trouble? Data analysis has to start
somewhere

Why Northern Ireland?



NI geology is a microcosm for the rest of the UK and Ireland.

High resolution sampling of Tellus data.

NICR complete incidence of all cancers occurring 1993 – 2003, mortality up to 2004.

6

Soil microcosm for uk

Soils: an essential hazard?

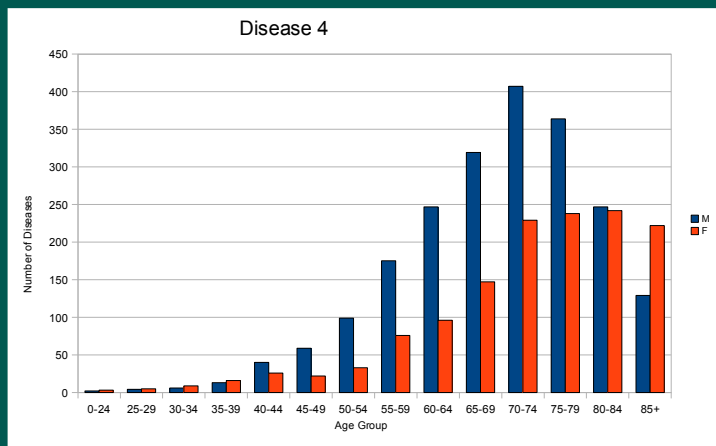
Essential nutrients in food eg. Se and Fe

Hazards – Natural :heavy metals, radon, pathogens

Anthropogenic: pollution

The NICR Data

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- postcode, age bracket (0-4, 5-9, 10-14 etc), gender & disease code.
- Aggregated postcodes to wards.



Tellus: Shallow soils total conc
Stream sediments
Water

Elements of interest: As Cd, Cr, Ni, Pb, Se, U (proxy for Rn, not a great one but Radon Risk will be available soon??) ask Cathy Sceibe @ BGS for this
Water nitrates

NICR: disease data
format

The Methods

- Age standardisation of the first 8 diseases – takes into account the 12 years over which the data are aggregated and the age structure of the population in which they occur
- Mapping the trace elements in the soils
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- Local Cluster Analysis (Local Moran's I)
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8

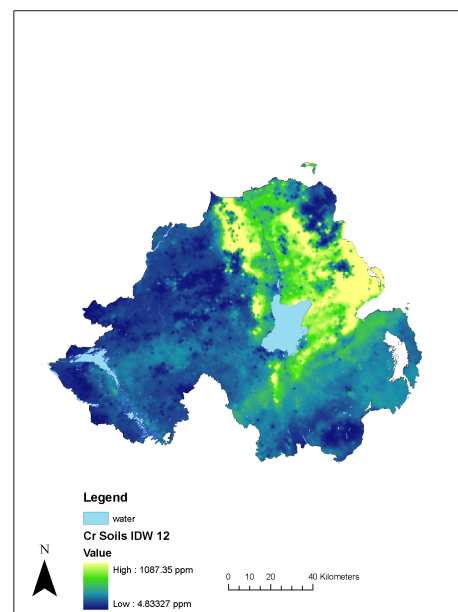
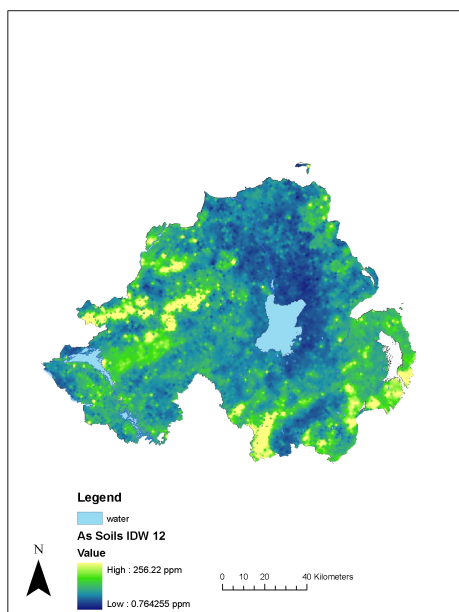
ArcGIS – mapping trace elements of interest
As, Cd, Cr, Ni, Pb, Se, U
IDW & Kriging

Age standardisation (2 methods)
Mapping diseases @ ward level
Variograms of asirs for spatial structure

Local moran's I maps for clusters (at ward level)

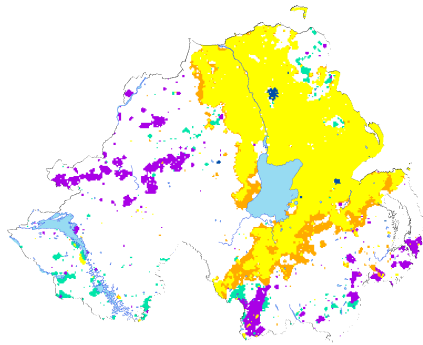
GWR

Tellus trace elements in shallow soils



Soil Guideline Values

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Cadmium	1 ppm
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Nickel	50 ppm
Lead	450 ppm

SGV's now out of date!

The Results

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- Cluster Hunter (GAM)¹ did not identify any hotspots in the raw data.
- DCluster:
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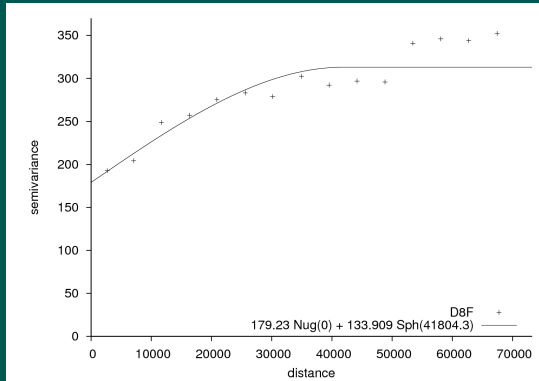
Cluster Hunter can not handle asir's

“An empirical Bayes index modification of Moran’s I for testing for spatial autocorrelation in a rate... The index value is tested by using nsim random permutations of the index for the given spatial weighting scheme, to establish the rank of the observed statistic in relation to the nsim simulated values.” (R. Bivand spdep handbook pg.5)

Negative (positive) values indicate negative (positive) spatial autocorrelation. Values range from -1 (indicating perfect dispersion) to +1 (perfect correlation). A zero values indicates a random spatial pattern.” (wikipedia, 1709, 12/5/09)

All the Diseases are slightly spatially autocorrelated, despite having taken out the effects of age distribution in the population, so what is causing this?

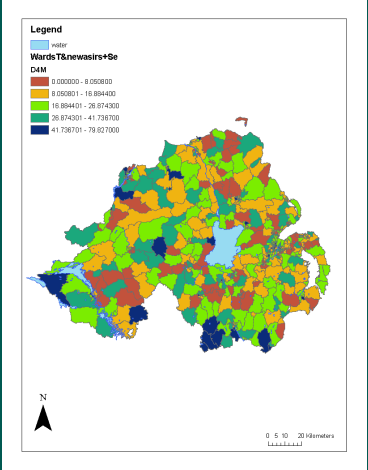
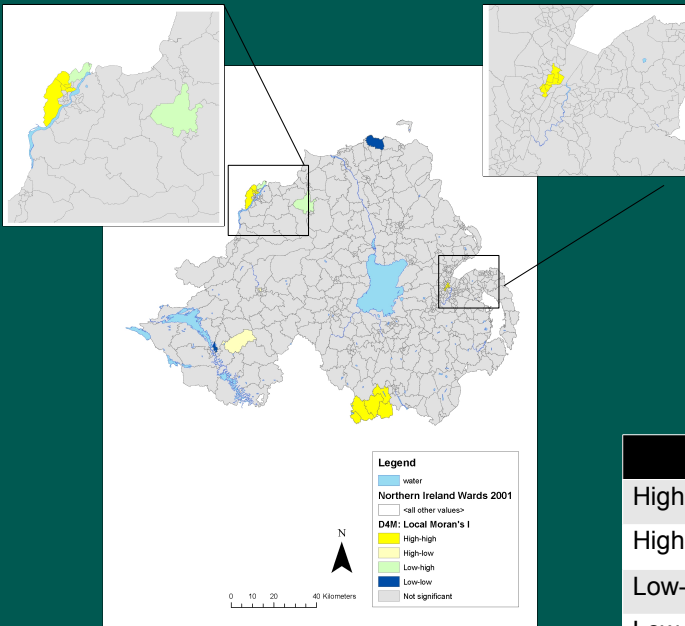
The Results



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All cancers diagnosed in January – interesting but not relevant

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D4M

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